Centre for Teaching Mathematics News

Issue 3 Summer 2001

Welcome

Welcome to the Summer edition of the CTM News. We publish this newsletter every term and will distribute it to schools, colleges and interested people. If you are reading somebody else's copy please contact the Centre secretary to be added to the mailing list. The newsletter will contain information on the staff and activities of the CTM. Each issue will contain a teaching resource which might be a graphic calculator activity, a problem solving activity or a practical mechanics problem.

We are sure you are eager for the end of term and wish you all a good Summer Break!

The Centre for Teaching Mathematics

The CTM is an inter-faculty group of mathematics educators based at the University of Plymouth within the Mathematics Department and the Education Faculty at Exmouth plus associate members.

The aims of the Centre are:
Creative Resources and Research
Training for Teachers
Mathematics Enrichment for Pupils

Contacting Us

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Mathematics Enrichment Programme

The team have had busy Spring and Summer terms with the Mathematics Enrichment Programme. The 6th Annual **Royal Institution Masterclass series** was held for year 9 students who are judged to be talented at mathematics. This year we had a record number of students attending - nearly 100 from all schools in Plymouth, SE Cornwall, Tavistock and South Hams. The classes were held on five alternate Saturday mornings and topics this year ranged from Traffic Flow Problems to the Mathematics of Rainbows. The feedback from the students was enthusiastic - "I was pleased to have been chosen because I enjoyed working on the problems that were set and I think I have learned a few different ways to go over a problem." " I thought that they were a good experience not only because it was the first time I had been to the University but also because I was learning a lot of things that I'd never learnt before." At the final session the students were presented with a certificate from the Royal Institution from Linda Gilroy MP. She said "it is one of the governments priorities to make provision for the most able students and this masterclass programme certainly addresses the needs of those students here in Plymouth." A follow up day- the **South West Masterclass Event**, was held in June and the Truro and Exeter groups were also invited to participate in a whole day of maths masterclasses.

The Centre also co-ordinated the Faculty of Technology's contribution to National Science Week. An **Engineering and Maths Trail** was held on 20th March for 150 year 9 students from local schools. The engineering, computing and maths department put on activities which provided the students with a taste of what it really is! Activities included Robot Football, Virtual Reality, Building a Spaghetti Tower, Will the Propeller Drop Off? Internet Traffic, Robotic Noughts and Crosses, Particle Physics and Topological puzzles. It was a huge effort by all involved but the day was thoroughly enjoyed by

both the students and the teachers who accompanied them.

At the end of May a three day **residential masterclass** was held for those students who attended last years Saturday masterclasses during the Summer half term. We took 15 students to St Albans to join a similar sized group from the Hatfield Masterclass programme. The students were subjected to maths, maths and more maths but they and we enjoyed it! Again they covered topics that they would not meet in school such as matrices and coding, proof and the mathematics of pi. The three days gave the students the opportunity to renew old friendships and to make new ones. Next year the Hatfield group will travel to Plymouth for the three days.

At the end of June we held our annual **VIth Form workshops** which are whole day activities for students just coming to the end of their Lower VIth. They spent the day being introduced to the ideas of mathematical modelling and tackling problems. It is quite different from the maths that is covered in school because to many of the problems there were no 'correct' answers, it could go which ever way the students chose to tackle it. One such problem in included in this issue.

Teacher Training News

At the time of writing our summer courses are in progress. We are running four courses for teachers this year, **Using Graphic Calculators at KS3**, **Teaching and Learning Mathematics with a Graphic Calculator** for teachers of A level and IB mathematics, **Decision and Discrete Maths** for those teachers who are new to this subject and **Modelling and Investigations in Mathematics** which is aimed at teachers of IB maths. Over the four courses we have nearly 40 teachers from all over the UK and from as far afield as The Netherlands, Italy, Sri Lanka and Jordan. It has been a great mix of teachers and as well as working hard there has been plenty of time for exchanging stories about teaching in different countries.

As well as the residential courses, the team is available to run training courses at the request of schools. The courses on using graphic calculators are subsidised by TI and so can be run in your school or area at a very reduced rate. Please contact us for more details.

Staff Profile: Nick Pratt

I current work at the University's Rolle School of Education in Exmouth, 50 miles distant from Plymouth, on B.Ed., PGCE and M.Ed. programmes as well as inservice work. Having originally graduated from Oxford with a degree in Engineering Science I gained my PGCE from the University of Exeter before working in a large First and Middle school in Exeter. A secondment to Rolle gave me the opportunity to try my hand in teacher education (now, of course, re-branded teacher 'training', but I hope that's not all we do!) and a permanent move ensued soon after.

Working in HE, I'm always amused by ex-colleagues in school who refer to me with the words 'now that you're not a teacher', as if, somehow, higher education is not about teaching. The context may be different perhaps, but the principles, and many of the skills, are the same, as is the buzz one gets from seeing people (of any age!) grappling with, and eventually understanding, new ideas. However, I'm now six years into the job and beginning to try to widen my horizons in terms of research. Teacher education, though, has not escaped the grip of the ever increasing documentation that seems to control what we must do in all educational contexts, including OfSTED, and this means that finding space for research has been hard. Nevertheless, I am currently coming towards the end of an M.Phil. which has been studying the effects on teachers of the introduction of the National Numeracy Strategy.

Why would I want to do research? After all, we can all fill our hours quite happily with the work we already have, so why impose more on myself? One reason, of course, is that I am 'supposed' to do it as part of my job. However, for me the real motivation is different. When I began I thought of research as a finished product; something that was published to inform other people about 'what's best' perhaps. Having begun now to be involved in it myself, I understand it much more as a process for myself. Although the publication of the work, in whatever form, is important, it is the thinking that is involved in doing it that

matters most. Actively exploring an issue forces one to understand the dilemmas inherent in it and to break out of the status quo that is the norm in teaching (how else could one survive?). Indeed my M.Phil. work has been about just that – how do teachers deal with the balance between maintaining the individuality of teaching and yet working more with the whole class, as they are instructed to do by the National Numeracy Strategy? In exploring this issue with teachers I've come to understand, not just the particular problems they face in 'direct interactive teaching' but have also come to understand my own teaching in a different way and how I interact with my own students. For example, one outcome for me has been to consider the way that interaction is 'genuine', in the sense that students' responses are valued and developed, rather than just being 'teaching fodder' for my own ends ("that's interesting Toby, I think what you really meant was…."; "stop there, because if we think differently about what you've just said we can see that….").

So, if anyone reading this article wants to engage in this process and has thoughts about the National Numeracy Strategy, particularly as it heads into secondary schools, I'd be glad to hear from you. Here are a few questions that you might like to respond to:

- Is the strategy about mathematics or numeracy, or are these the same thing?
- How does one work 'interactively' with the whole class and, at the same time, follow up the ideas of individual children?
- Do children really learn from each other effectively by listening to others' explanations (I'm not sure I could understand most of them!)?
- Is a greater centralisation of curriculum and teaching 'method' for teachers simply turning them into 'technicians' or creating a new professionalism?
- Most importantly, is the National Numeracy Strategy going to produce children who are genuinely better at mathematics (whatever you think that is), or simply make them better at what is testable?

Answers on a postcard to sunny Exmouth please…..**npratt@plymouth.ac.uk**

Student Centred Learning in H.E.

What is it?

Student Centred Learning (SCL) is about students participating more actively in the learning process (essentially it is exploiting the 'I do and I understand' philosophy of education). It embraces the six principles of good learning as presented by de Corte (1993): constructive; self regularity; cumulative; cooperative; goal orientated and contextual. It is about students becoming more responsible for, and more fully involved in, their education. allowing them to be involved in their learning and being willing to reflect on, and discuss, their work.

Why now?

Mathematics is not a completed body of knowledge to be transmitted to students for return at times of assessment. Mathematics education is, or should be, about understanding concepts and developing problem solving skills. The skills mentioned above require dialogue, teamwork, communication and reflection. In short they require ACTION and PARTICIPATION. To develop graduates who possess such skills requires a change in the teaching styles to which they are exposed. There needs to be a shift to greater student activity in the classroom and a greater acceptance of responsibility for their own learning.

How?

Surveys of student learning styles reveal that not all students can learn effectively from a book (Devlin, 2000). Therefore in order for teaching to be maximally effective, students must be exposed to a wide variety of teaching methodologies in order to engage as many of them as possible. For example, one strategy involves an adaptation of the Problem Based learning approach and uses Case Studies in an integrated way to introduce and develop the content of the module through a process of guided discovery (Townend, 2001). As the following outline shows the students are actively involved in student-student and student-tutor dialogue.

(i) Introduce a problem to the whole class (with the intention of identifying specific mathematical topics);

(ii) Let the students discuss the problem in small groups with the objective of identifying the potential mathematics for themselves;

(iii) A plenary session in which all the student ideas are bought together and attention focused on those identified by the tutor as relevant;
(iv) A tutor led session of directed discussion to establish the desired mathematics which is then used to solve the original problem. Finally any necessary other aspects of the mathematical topic are addressed so that the overall educational experience is coherent.

SCL and Assessment

The common assessment model of a timed, closed book examination has outlived its usefulness. It is not of itself bad practice, it served well in the 1960's and '70's when our students were, by and large, prepared for a lifetime career in a large company or public service. Today however the small to medium employer is the cornerstone of the economy. These require employees who are flexible, creative, innovative and who have the ability to learn new skills as necessary. These skills are best assessed by groupwork and portfolio based on a problem solving approach rather than the more traditional, algorithmic assessment. Other methods of assessment such as peer assessment have also been successfully incorporated into SCL programmes. Student involvement in self/peer review promotes the power of self evaluation – a skill which remains after assessment is completed.

Measuring the value of SCL

SCL has been shown to be effective in the sense that the cooperative learning experience leads to higher achievement (Johnson & Johnson 1987). The portfolio serves to demonstrate to the world outside education that SCL enhances student learning by providing evidence of the problem based learning and as an indicator of the key skills required.

Informed Students

If students are to be exposed to changes in the styles of teaching presented to them then they have a right to know why. The introduction of student fees implies that they have a consumer contract with their university and litigation will surely follow if they are disappointed with the quality of the course or the teaching received. Whatever teaching models are adopted it is paramount that the students are made explicitly aware that they are involved in a learning partnership.

What are the Potential Problems?

The initial student expectation of a course is often a transmission model of delivery in which they are mainly passive, any activity being limited to mimicry of the procedures and examples being presented by the instructor. They are therefore somewhat taken aback by the realisation that they are expected to be active and involved in an environment focused more on applications, projects and problem solving than on theory and procedural mimicry. Despite some initial misgivings amongst their student sample, Berry & Sharp (1999) report positive reactions to SCL based courses. It works well with more mature students and for class sizes below about 30. Year 1 groups tended to be too large and easily disrupted due to the immaturity of some individuals expecting a school type approach to the teaching.

The Way Forward

SCL is believed to offer an approach to undergraduate learning that fits easily into the lifelong learning espoused by Dearing. Although its use is so far 'patchy' the benefits are clear. Berry & Sharp include comment from a mature student who experienced a complete conversion from 'anti' to 'pro'. A major longitudinal study is needed to assess whether the benefits are long term. In order to retain and develop staff support for SCL initiatives universities will need to ensure that clear promotional pathways exist for those staff prepared to put the time and effort into developing the ethos of SCL

References

de Corte, E. (1993), *Learning Theory and Instructional Science,* paper presented at the Final Planning Workshop of the ESF programme 'Learning in Humans and Machines', St Gallen, Switzerland.

Berry, J. & Sharp, J. (1999) *Developing Student Centred Learning in Mathematics through Cooperation, Reflection and Discussion*, Teaching in Higher Education, 4, 1, pp 27-41.

Devlin, K. (2000), *Bye, bye American pi – textbooks can't teach maths to most young US students*, The Guardian, 13 Jan 2000.

Johnson, D.W. & Johnson, R.T. (1987), *Learning Together and Alone: Cooperative, Competitive and Individualistic Learning* (London, Prentice Hall)

Townend, M.S. (2001), *Integrating Case Studies in Engineering Mathematics: a response to SARTOR 3*, Teaching in Higher Education, 6, 2, pp 203-215

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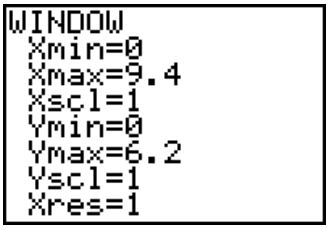
Co-ordinates

Although this activity is based on the TI-83 other graphic calculators can do similar things. It is an activity referred to in the KS3 National Strategy for Mathematics document.

The TI-83 can draw straight lines and circles. For straight lines you need to tell it the starting co-ordinate and the end co-ordinate. The command Line(0,2,3,6) will draw a line starting at the point (0,2) and ending at the point (3,6).For circles you need to tell it the co-ordinates of the centre of the circle and the radius of the circle. The command Circle(0,2,1) will draw a circle with its centre at (0,2) and it will have a radius 1.

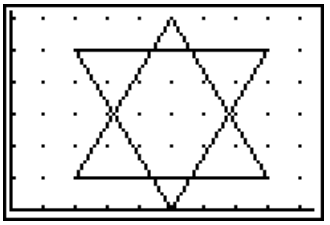
The [WINDOW] needs to be set up as shown.
This ensures that circles come out as circles



The [FORMAT] needs to be as shown.

Make sure that there is nothing in [Y=] and that any PLOTS are turned off.

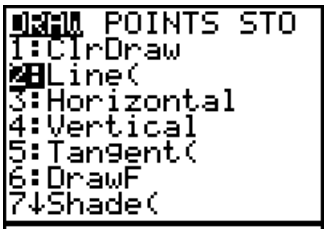
To draw a star



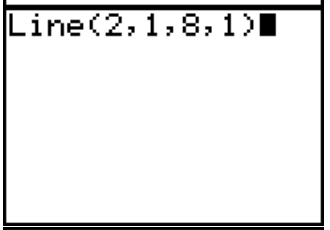
The first task is to write down the coordinates of the six points on the star.
.....
.....

The next step is to write down the commands for the six lines that the star needs i.e. Line(*,*,*,*)
.....
.....

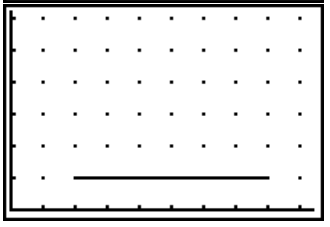
Now we can draw our star. You need to be in the Home screen to write the commands which are in [DRAW].
Choose 2:Line(and press [ENTER]



This command should now be on you home screen. Enter the starting and finishing coordinates of you first line.



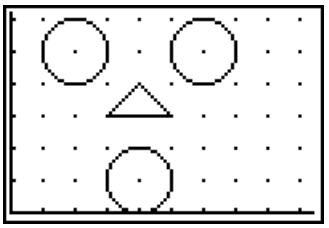
Press [ENTER] and the line should appear.



You need to get back to the Home screen to get the command for the next line so press [QUIT]. Enter the command for the second line and press [ENTER], your line should appear. Continue until you have your star.

If you make a mistake you need to clear the whole picture and start again!
Use ClrDraw from [DRAW]
You can save your pictures. [DRAW], across to STO, choose StorePic and give it a number between 0 and 9. Recall in a similar way.

Drawing a Face



Delete your star: [Draw], ClrDraw.

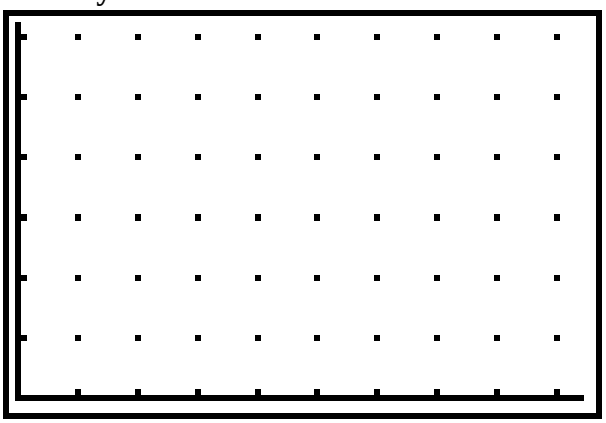
Now list the commands for the face: Remember the Circle needs the centre coordinate and the radius

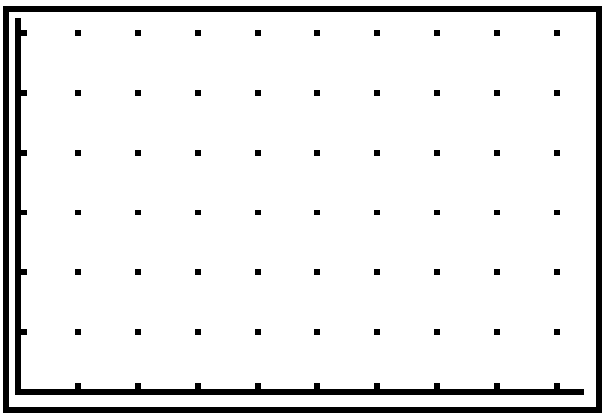
.....

.....

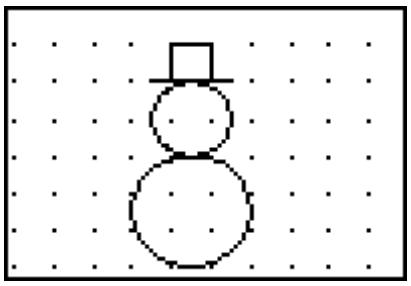
.....

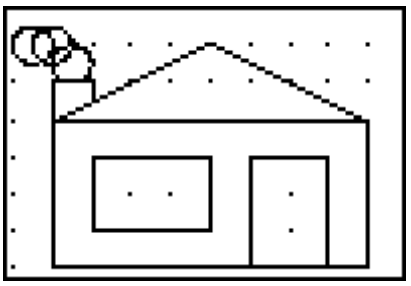
Create your own!

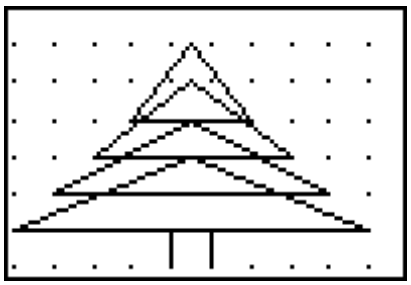


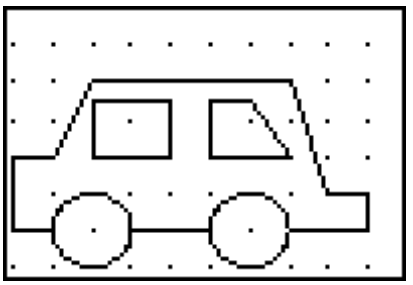


Students pictures



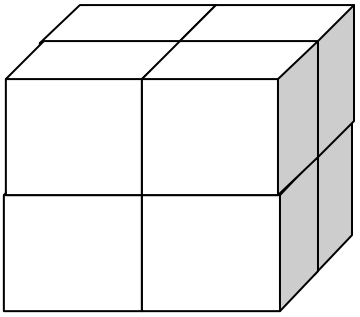






An Investigation in Pure Mathematics

Cubist Painting



A 2cm $\times$ 2cm $\times$ 2cm cube is painted pink. It is then cut into 1cm^3 pieces and the pieces are rearranged so that no pink paint can be seen and the whole cube is then pained green. How is each 1cm^3 painted?

Is it possible to paint a 3cm $\times$ 3cm $\times$ 3cm cube pink, green and orange? If so, how is each 1cm^3 painted? What about a 4cm $\times$ 4cm $\times$ 4cm cube?

Hints and Nudges

(i) Consider the total surface area of all the seperate 1cm^3 cubes. Is it large enough for the different coats of paint on the large cubes?

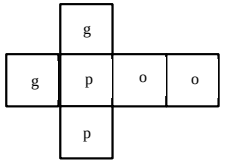
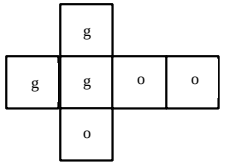
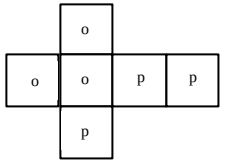
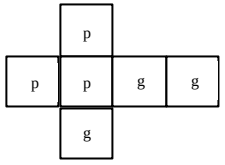
(ii) When a large cube is painted in one cloour, how many little cubes have three faces painted? How many have two faces painted? How many have one face painted? How many have no faces painted?

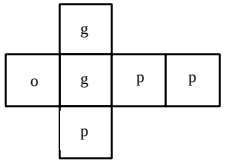
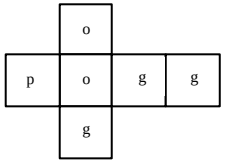
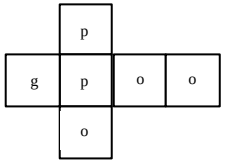
Teachers notes on Cubist paintings

For the 2cm × 2cm × 2cm cube each small cube is painted with three sides of each colour:

For the 3cm × 3cm × 3cm cube for each colour you will need 8 corner cubes with 3 faces painted; 12 edge cubes with 2 faces painted, 6 face cubes with 1 face painted and 1 inner cube not painted in that colour. There are various ways of painting the individual cubes and various notations that may be adopted. The easiest way check a solution in any notation is to check that (i) each cube has 6 faces painted, (ii) there are 27 cubes (iii) for each colour there are the cubes listed above.

Here is one solution, (there are obviously others)

Net of Cube	Number of Cubes	Position in large cube
	12	Edge Cubes for all three colourings
	1	Corner Cube for green and orange Inner cube for pink
	1	Corner Cube for pink and orange Inner cube for green
	1	Corner Cube for pink and green Inner cube for orange

Net of Cube	Number of Cubes	Position in large cube
	6	Corner Cube for pink Edge Cube for green Face cube for orange
	6	Corner Cube for green Edge Cube for orange Face cube for pink
	6	Corner Cube for orange Edge Cube for pink Face cube for green

For the 4cm × 4cm × 4cm cube for each colour you will need 8 corner cubes with 3 faces painted; 24 edge cubes with 2 faces painted, 24 face cubes with 1 face painted and 8 inner cube not painted in that colour.